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Legal-IP Dept., Mail Stop S316A
6900 Main Street
Stratford, CT 06615-9129

EXAMINER
NGUYEN, XUAN LAN T

ART UNIT	PAPER NUMBER
3683	

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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	**Application No.** 10/685,053	**Applicant(s)** WELSH ET AL.
	Examiner Lan Nguyen	**Art Unit** 3683

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *16 February 2005*.
2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.
3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1,2,4 and 11-28* is/are pending in the application.
4a) Of the above claim(s) _____ is/are withdrawn from consideration.
5)☐ Claim(s) _____ is/are allowed.
6)☒ Claim(s) *1,2,4 and 11-28* is/are rejected.
7)☐ Claim(s) _____ is/are objected to.
8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.
10)☒ The drawing(s) filed on *16 February 2005* is/are: a)☐ accepted or b)☒ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a)☐ All b)☐ Some * c)☐ None of:
1.☐ Certified copies of the priority documents have been received.
2.☐ Certified copies of the priority documents have been received in Application No. _____.
3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☒ Other: Translation (JP 2001 099739 A) + drawings

P

DETAILED ACTION

Drawings

1. The replacement drawings were received on 2/16/05. Figures 1, 2 and 3a-3c are approved. Figures 4 and 5 are NOT approved because: figure 4 introduces new matters (box 46 and box 40); and figure 5 introduces new matter of magnet 35'.

2. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(4) because reference characters "32 and 36" are both used for electromagnets, and "28 and 33" are both used to designate the coils.

3. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description: 32' and 60s.

4. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Specification

5. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The specification is objected to under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement because of the following reason.

It is unclear how the permanent magnet 35' would mix the MRF and where it is located in relationship with the chamber 22 and the electromagnets 32. The invention is about effecting the distribution of the MR fluid within the housing 20 by energizing coil(s) 28 of the electromagnet(s) 32. By having permanent magnet(s) 35' disposed adjacent the housing 20, the MRF is mixed. However, it is unclear how the MRF is affected or mixed by the magnet(s) 35' alone and in combination with electromagnets 32.

It is required that an explanation be provided for the above mentioned reason in a response to this Office Action.

6. The amendment filed 2/16/05 is objected to under 35 U.S.C. 132(a) because it introduces new matter into the disclosure. 35 U.S.C. 132(a) states that no amendment shall introduce new matter into the disclosure of the invention. The added material which is not supported by the original disclosure is as follows:

- In paragraph [00027], next to the last line, "from a stationary system such as a fuselage".
- In paragraph [00028], lines 9-18, the added portion starting with "The power source 60" and ending with "exactly track rotor speed".

Applicant is required to cancel the new matter in the reply to this Office Action.

7. The specification is further objected to because:

- In paragraph [00031], line 4, the phrase "P2 produced by the 2" is believed to comprise a typographical error since this phrase does not make sense.

Appropriate correction is required.

Claim Objections

8. Claim 4 is objected to because of the following informalities: the preamble of claim 4 does not match claim 1.

9. Claim 24 is objected to because of the following informalities: line 9, "to reduces" should be -- to reduce--.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

10. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

11. Claims 18, 19, 24, 25, 26 and 28 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

- Re: claim 18, see the objection to new matters in the specification objections above.
- Re: claim 19, claimed limitation "sensor phase".
- Re: claim 24, claimed limitation "reducing phase".
- Re: claim 25, claimed limitation "predetermined schedule".
- Re: claim 26, claimed limitation "a trend in a variation ... in response to the trend".
- Re: claim 28, see the objection to new matters in the specification objections above.

12. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

13. Claims 1, 2, 4, 19 and 21-23 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

- In claims 1 and 21, the term "selectively" renders the claims indefinite.
- Claim 19 recites the limitation "said electric motor" in line 3. There is insufficient antecedent basis for this limitation in the claim.

Claim Rejections - 35 USC § 103

14. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and

> the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

15. Claims 1, 2, 4 and 11-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Case et al. in view of Hooper.

Re: claim 1, Case et al. show a vibration isolation system for reducing vibrations in a rotating system rotatable about an axis of rotation in figure 4, as in the present invention, comprising: a housing 62 mounted to said rotating system and defining an internal chamber 282; a Magneto Rheological Fluid (MRF) 284 disposed in said chamber, and means 290 for distributing said MRF within said chamber to form an eccentric mass which reduces a vibratory load active in said rotating system, as shown in figure 4. Case's housing 62 rotates with the shaft 20. Hooper teaches the concept of having the vibration isolation system 14 rotates independently of the rotating system 21 of the main rotor 12 in order to not only suppressing the vibration from the rotating system but also the vibration from external sources such as wind in column 2, lines 15-26. It would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified Case's vibration isolation system such that the housing could rotate independently of the rotating system as taught by Hooper in order to not only suppressing the vibration from the rotating system but also the vibration from external sources.

Re: claims 2 and 4, Hooper further shows a drive system 30, 39 for driving the housing 28 at a rotational speed greater than the rotational speed of said rotating system using the calculation as claimed, in column 1, lines 27-35. Case shows electromagnets 290 disposed in combination with said housing 62 and adjacent said internal chamber 282 for rotating therewith; power source 72; and control system 42 as claimed.

Re: claim 11, Case et al. show a method for reducing vibrations in a rotating system, as in the present invention, comprising: enclosing a medium 284 of variable viscosity in a housing 62 connected to the rotating system 20; sensing a rotational speed of the rotating system as shown in figure 10, issuing a control signal responsive to the rotational speed, the control signal activating a means 290 to change the viscosity of the medium; and redistributing the medium within the housing to reduce vibratory loads in the rotating system. Case's housing 62 rotates with the shaft 20. Hooper teaches the concept of having the vibration isolation system 14 rotates faster than the rotating system 21 of the main rotor 12 in order to not only suppressing the vibration from the rotating system but also the vibration from external sources such as wind in column 2, lines 15-26. It would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified Case's method for reducing vibration to include a housing that could rotate faster than the rotating system as taught by Hooper in order to not only suppressing the vibration from the rotating system but also the vibration from external sources.

Re: claim 12, Case et al. show a vibration isolation system for reducing vibrations in a rotating system which rotates about an axis of rotation in figure 4, as in the present invention, comprising: a housing 62 defining an internal chamber 282, said housing mounted to said rotating system 20 for rotation about said axis of rotation of the rotating system; a Magneto Rheological Fluid 284 (MRF) partially filling said internal chamber, see column 13, lines 39-42, and an electromagnetic field generation system 290 mounted adjacent said internal chamber to azimuthally vary a viscosity of said MRF and distribute said MRF within said internal chamber to reduce a vibratory load in said rotating system, as shown in figure 4. Case's housing 62 rotates with the shaft 20. Hooper teaches the concept of having the vibration isolation system 14 rotates independently of the rotating system 21 of the main rotor 12 in order to not only suppressing the vibration from the rotating system but also the vibration from external sources such as wind in column 2, lines 15-26. It would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified Case's vibration isolation system such that the housing could rotate independently of the rotating system as taught by Hooper in order to not only suppressing the vibration from the rotating system but also the vibration from external sources.

Re: claims 13-15, in column 1, lines 30-35, Hooper teaches the rotational speed of the housing as claimed.

Re: claim 16, Hooper shows main rotor system 12.

Re: claim 17, Hooper shows drive system 30, 39.

Re: claim 18, Hooper shows that the speed of the housing is greater than the speed of the main rotating system hence the drive system has to be controlled accordingly.

Re: claim 19, Case shows vibration sensor 48 to feedback for the controlling scheme.

Re: claim 20, Case further shows multiple electromagnets 290.

16. Claims 21-28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hooper in view of Case et al.

Re: claim 21, Hooper shows a helicopter rotor system 12 which rotates about an axis of rotation, comprising: a main rotor assembly 12 having an N number of blades which rotates about an axis of rotation at a rotational speed of 1P, such that said main rotor system produces NP vibrations, see column 1 lines 30-35; a housing 28 defining an internal chamber, said housing mounted to said main rotor assembly for rotation about said axis of rotation independent of said main rotor assembly as shown. Hooper uses a vibration isolation device with movable eccentric masses 50, 51, 53 and 54 to balance the shaft 21 in order to reduce vibration. Case et al. teach a vibration isolation device that also uses eccentric masses but without internal moving parts comprising: a housing 62 partially filling with an MR fluid 284, see column 13, lines 39-42; a sensor system 48, a control system 42 in communication with said sensor system, and an electromagnetic field generation system 290 mounted within said housing for rotation therewith and adjacent said internal chamber to azimuthally vary a viscosity of said MRF and distribute said MRF within said internal chamber to form an eccentric mass in response to said control system to reduce said vibrations, as shown in figure 4. It would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified Hooper's helicopter with a vibration isolation device such as Case's in order to dampen a wide range of frequency at the same time reducing internal moving parts which in turn would reduce the overall weight of the device as taught by Case. Note that Hooper's helicopter as modified by Case's vibration isolator would have the same control scheme wherein the goal is to dampen out NP vibration as stated by Hooper in column 1, lines 30-35.

Re: claims 22 and 23, Hooper further shows drive system 30, 39 and the calculation in column 1, lines 30-35.

Re: claim 24, Hooper shows a method of reducing vibrations in a helicopter rotor system which rotates about an axis of rotation, as in the present invention, comprising the steps of: rotating a housing 28 mounted to a main rotor assembly 12 about the axis of rotation independent of the main rotor assembly, the housing having an internal chamber; and varying an electric motor speed of the drive 30, 39 that drives the housing to match the optimal load based upon controller commands. Hooper's method lacks a MRF dampener. Case teaches a method using an MRF dampener comprising: providing a housing 62 having an internal chamber 282; and at least partially filled with a Magneto Rheological Fluid (MRF); sensing a vibration by sensor 48 generated by the rotating assembly; varying an electromagnetic field about the internal chamber to azimuthally vary a viscosity of said MRF and distribute said MRF within said internal chamber to form an eccentric mass in response to said sensed vibration to reduce the vibration, as shown in figure 4. It would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified Hooper's method of reducing vibration in a helicopter with the use of a vibration isolation device such as Case's in order to dampen a wide range of frequency at the same time reducing internal moving parts which in turn would reduce the overall weight of the device as taught by Case.

Re: claims 25 and 26, Case shows in figure 10 that the device can be controlled based on a predetermined schedule and a detected trend.

Re: claim 27, Case shows the eccentric mass.

Re: claim 28, Hooper teaches in column 1, lines 30-35 the typical vibration in a helicopter and in figure 3, drive system 30, 39 to drive the dampener to cancel out the frequencies.

Response to Arguments

17. Applicant's arguments with respect to the claims have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

18. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Dyer et al. show another device to balance a rotating system with rotors 350, 351 rotating independent of the shaft.

19. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

20. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Lan Nguyen whose telephone number is (571) 272-7121. The examiner can normally be reached on M-F, 8 to 4:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Charles Marmor can be reached on (571) 272-7095. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Lan Nguyen
Primary Examiner
Art Unit 3683

5/12/05

PTO 05-0428

CY=JA DATE=20010413 KIND=A
PN=13-099739*

TRANSLATION JP 2001099739A

ROTOR BALANCER
[Kaitentai no baransu shuusei souchi]

Yoshiaki Kai

UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. November 2004

Translated by: FLS, Inc.

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INVENTOR	(72):	KAI, YOSHIAKI
APPLICANT	(71):	TOSHIBA MACHINE CO., LTD.
TITLE	(54):	ROTOR BALANCER
FOREIGN TITLE	(54A):	KAITENTAI NO BARANSU SHUUSEI SOUCHI

[Claims]

[Claim 1] A rotor balancer for correcting imbalances of a rotor characterized by being equipped with:

a means for detecting the rotation reference position of said rotor;

a means for detecting the degree of amplitude of the radial vibration of said rotor with respect to the shaft center;

a control means for calculating said rotor's imbalance angular position and imbalance amount based on the results detected by said means for detecting the rotation reference position of said rotor and by said means for detecting the degree of amplitude of the radial vibration of said rotor with respect to the shaft center;

a ring-shaped hollow part provided to said rotor in a manner such that the center is at the rotor's rotational center;

a plurality of electrode plates provided in pairs to inner wall surfaces that are perpendicular to the rotation central axis of the hollow part and in the direction of the shaft center;

an electroviscous fluid injected inside said hollow part at a quantity less than the interval volume of said hollow part; and

a voltage application means for applying voltage between said electrode plates that are of the opposite phase from that of the imbalance angular position of said rotor based on an instruction from said control means.

[Claim 2] A rotor balancer characterized by a plurality of said electrode plates being provided in the radial direction of said hollow part.

[Detailed Explanation of the Invention]

[0001] [Field of the Invention]

The present invention pertains to devices for correcting the dynamic imbalances of rotors, specifically to rotor balancers for reducing the vibration of rotors and for increasing their rotational accuracy.

[0002] [Related Art]

For the correction of dynamic imbalances of main shafts or rotary shafts that are used as rotors in machine tools, the imbalance angular position and the degree of imbalance were measured by means of a dynamic balance tester and a corrective weight was added to a screw hole, which was provided for balancing, at the main shaft's end face or at an optional location or the imbalanced portion was shaved off in the past. Also, a test for the post-assembly dynamic balance called field balance was carried out during trial runs.

[0003] [Problems that the Invention is to Solve]

However, the method in which a corrective weight is added to a screw hole for balancing and the method in which the imbalance portion is shaved off are for balancing the rotary shaft as a single unit before the main shaft is assembled. Therefore, imbalances occurred occasionally due to errors caused by assembling. Moreover, since a dynamic balance test is carried out after the main shaft has been assembled, the balancing surface becomes limited. Therefore, if the imbalance is corrected at the main shaft's end face when the imbalance is at the center of the main shaft, a bending force was occasionally applied to the main shaft. Moreover, the above-described methods have a problem in that dynamic balancing cannot be performed unless the machine is stopped.

[0004] The present invention solves the above-described problems, and its purpose is to supply rotor balancers capable of correcting imbalances without requiring the main shafts to be reassembled for balancing.

[0005] [Means for Solving the Problems]

In order to achieve the above purpose, a rotor balancer of the present invention is equipped with: a means for detecting the rotation reference position of the rotor; a means for detecting the degree of amplitude of the radial vibration of said rotor with respect to the shaft center; a control means for calculating said rotor's imbalance angular position and imbalance amount based on the results detected by said means for detecting the rotation reference position of said rotor and by said means for detecting the degree of amplitude of the radial vibration of said rotor with respect to the shaft center; a ring-shaped hollow part provided to said rotor in a manner such that the center is at the rotor's rotation center; a plurality of electrode plates provided in pairs to inner wall surfaces that are perpendicular to the rotation central axis of the hollow part and in the direction of the shaft center; an electroviscous fluid injected inside said hollow part at a quantity less than the interval volume of said hollow part; and a voltage application means for applying voltage between said electrode plates that are of the opposite phase from that of the imbalance angular position of said rotor based on an instruction from said control means.

[0006] In such a structure, voltage becomes applied between the electrode plates that are of the opposite phase from that of the imbalance position of the rotor based on an instruction from the control means. By this, the electroviscous fluid becomes more viscous and fixated as a weight between those electrode plates, and the rotor's imbalance becomes corrected.

[0007] Moreover, it is preferred that a plurality of said electrode plates be provided in the radial direction of said hollow part.

[0008] [Working Mode of the Invention]

In the following, a working mode of the present invention will be explained by referring to Figs. 1 and 2. Figure 1 is a cross-sectional drawing of a rotor balancer [11] of the present invention attached to the rotary shaft [20] of a spindle unit, which is a machine tool. Figure 2 is the balancing ring [14] of a rotor balancer [11] of the present invention, and (a) is its vertical cross-sectional drawing and (b) is a horizontal cross-sectional drawing of the line A-A of (a). The rotary shaft [20] is attached to a casing [22] by means of two bearings [21]. The center of the interior of the casing [22] is provided with a rotation reference position detector [12], which is a means for detecting the rotation reference position of the rotor, and a displacement detector [13], which is a means for detecting the amplitude of the radial vibration of the rotor with respect to the shaft center.

[0009] The rotation reference position detector [12] detects the rotation reference position by providing the shaft center of the rotary shaft [20] with a rotation reference position, which acts as a reference of rotation, by means of etching, etc. by using a noncontact-type photoelectric switch, etc. and by receiving reflected light from the rotary shaft [20] during rotation. The displacement detector [13] is a noncontact eddy-current-type or capacitance-type displacement detector or a laser displacement detector. It detects the amplitude of the radial vibration of the rotary shaft [20] with respect to the shaft center by detecting the variation in the distance between a detecting sensor [13a], which is provided at the front end, and the rotary shaft [20]. The control device [15], which acts as a control means, calculates the rotary shaft's [20] single or multiple imbalance angular positions and their imbalance amounts.

[0010] Moreover, the balancing ring [14] is inserted and fitted into the center part of the rotary shaft [20] together with a voltage applying device [16], which acts as a voltage applying means. The interior of the balancing ring [14] is provided with a ring-shaped hollow part [17] as shown in Fig. 2(a) and (b). The interior of this hollow part [17] is provided with electrode plates [18] that are paired on the inner wall surfaces perpendicular to the rotating central shaft. These are provided by 8 pairs in the axial direction and by 3 pairs in the radial direction. Moreover, the interior of the hollow part [17] has injected in it an electroviscous fluid (ER fluid) [19] that is enough to cover all of the three pairs of electrode plates [18] of the lowest angular position as shown in Fig. 2(b).

[0011] The above control device [15] is structured so that, in accordance with the imbalance angular position and imbalance amount of the rotary shaft [20], it determines which electrode plates [18] located at which angular position of the balancing ring [14] and at which radial position should have voltage applied to them.

[0012] As shown in Fig. 1, the rotary shaft [20] is provided with the voltage applying device [16] adjacent to the balancing ring [14]. This voltage applying device [16] has a built-in battery not illustrated and applies voltage between the electrode plates [18] of the opposite phase from the imbalance position in response to a wired or wireless instruction from the control device [15]. Because of the properties of the ER fluid [19], this increases the viscosity of the ER fluid [19], and the ER fluid [19] becomes fixated only between the pair of electrode plates [18] that had the voltage applied to them.

[0013] Next, the operation of the present invention will be explained. The rotary shaft [20] is made to rotate. Based on the rotation reference position of the rotary shaft [20] detected by means of the rotation reference position detector [12] and the amplitude of the radial vibration of the rotary shaft [20] with respect to the shaft center detected by means of the displacement detector [13], the control device [15] calculates the imbalance angular position and the imbalance amount of the rotary shaft [20]. The control device [15] determines which electrode plates [18] of the balancing ring [14] should have voltage applied to it based on the imbalance angular position and the imbalance amount of the rotary shaft [20], and sends a wired or wireless instruction to the voltage applying device [16]. After receiving the instruction from the control device [15], the voltage applying device [16] applies voltage between the instructed electrode plates [18].

[0014] At this time, by temporarily rotating the rotary shaft [20] at a low speed, the ER fluid [19] becomes fixated between the electrode plates [18] that had voltage applied to them. By then returning the rotary shaft [20] to high-speed rotation, the ER fluid [19] that became fixated between the electrode plates [18], which had the voltage applied to them, turns into a weight and corrects the imbalance of the rotary shaft [20]. The remainder of the ER fluid [19] sticks evenly to the entire inner periphery of the hollow part [17] because of the centrifugal force as the rotary shaft [20] rotates.

[0015] The above-described working mode is an example of a case in which the present invention is attached to the main shaft of a machine tool, but it is also possible to correct imbalances by attaching a balancing ring [16] to both ends of the rolls of printers, extruders, etc. or by attaching a balancing ring [16] to the turbines of power generators.

[0016] [Effects of the Invention]

As described earlier, a rotor balancer of the present invention can correct imbalances without requiring the main shaft to be reassembled for balancing. It is also capable of correcting imbalances at areas that are hidden by, for example, the cover of the rotary shaft and that could not be reached in the conventional balancing process, which takes place after the rotor has been assembled.

[Brief Explanation of the Drawings]

[Figure 1] A cross-sectional drawing showing an example of a working mode in which the present invention is attached to the main shaft of a machine tool.

[Figure 2] A balancing ring for balancing a rotor of the present invention. (a) is a vertical cross-sectional drawing and (b) is a horizontal cross-sectional drawing of the line A-A of (a).

[Explanation of the Reference Numerals]

[11] = rotor balancer

[12] = rotation reference position detector

[13] = displacement detector

[14] = balancing ring

[15] = control device

[16] = voltage applying device

[17] = hollow part

[18] = electrode plate

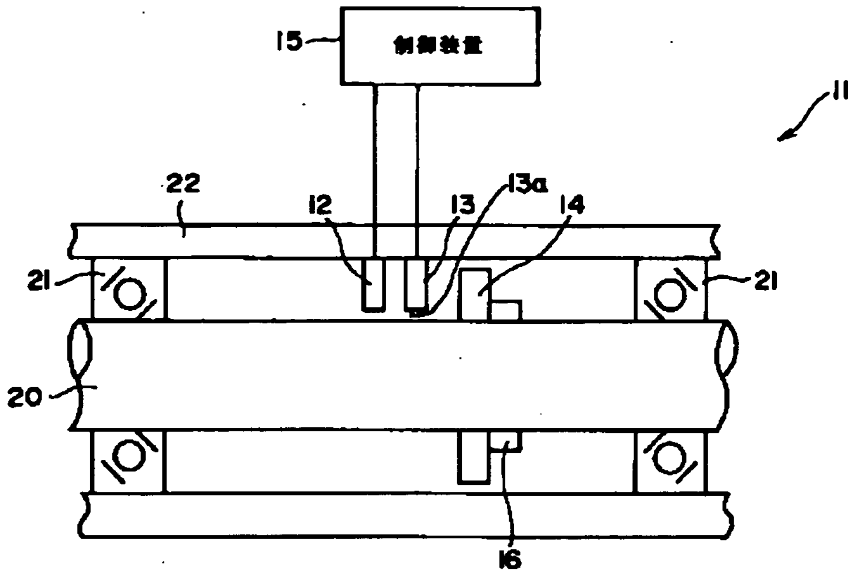
[19] = ER fluid

[20] = rotary shaft

[21] = bearing

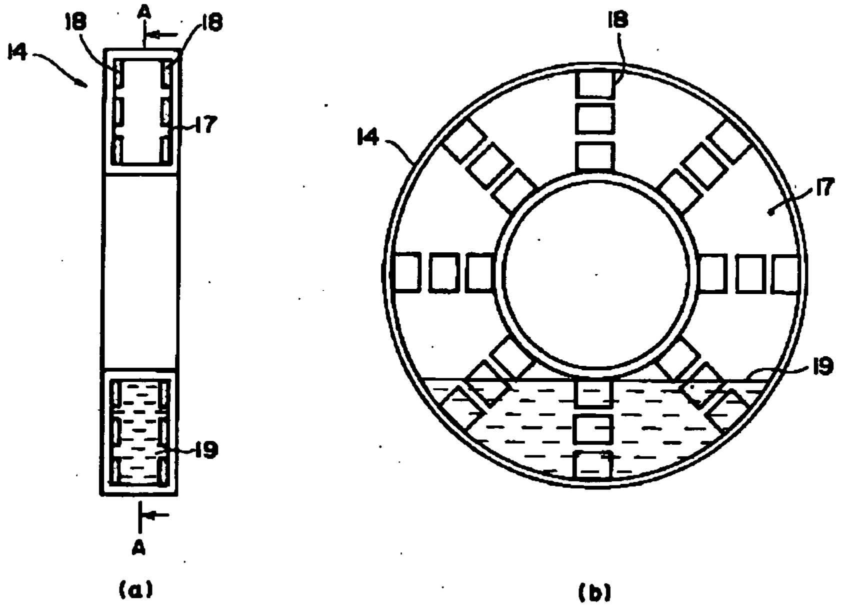
[22] = casing

[Figure 1]



Key: 15) control device.

[Figure 2]



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ACTIVE FORCE GENERATION/ISOLATION SYSTEM
EMPLOYING MAGNETO RHEOLOGICAL FLUID (MRF)

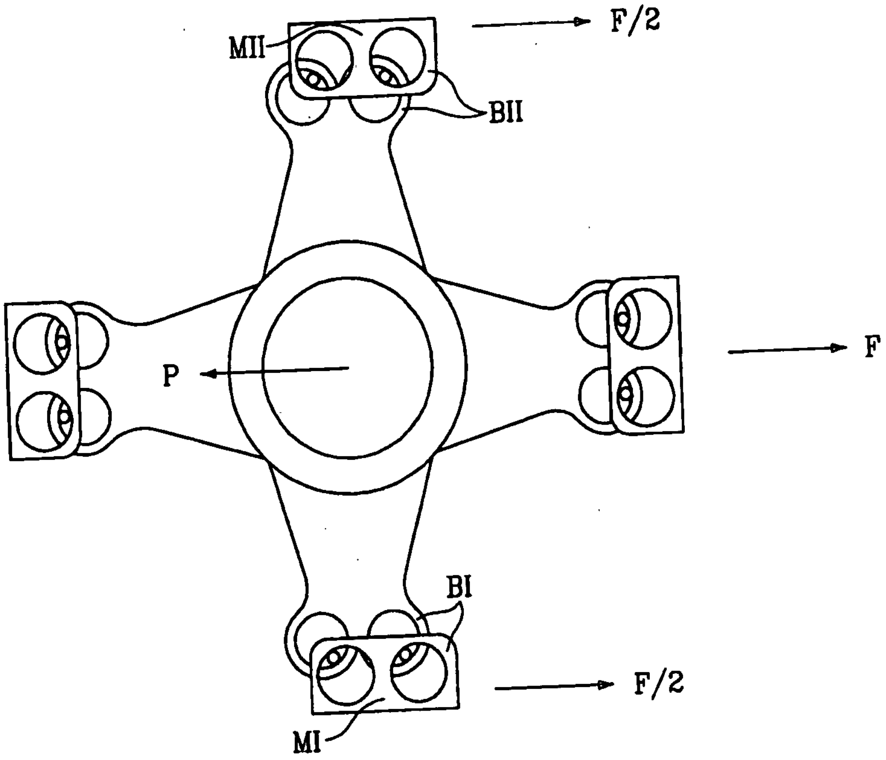

FIG. 1
(PRIOR ART)

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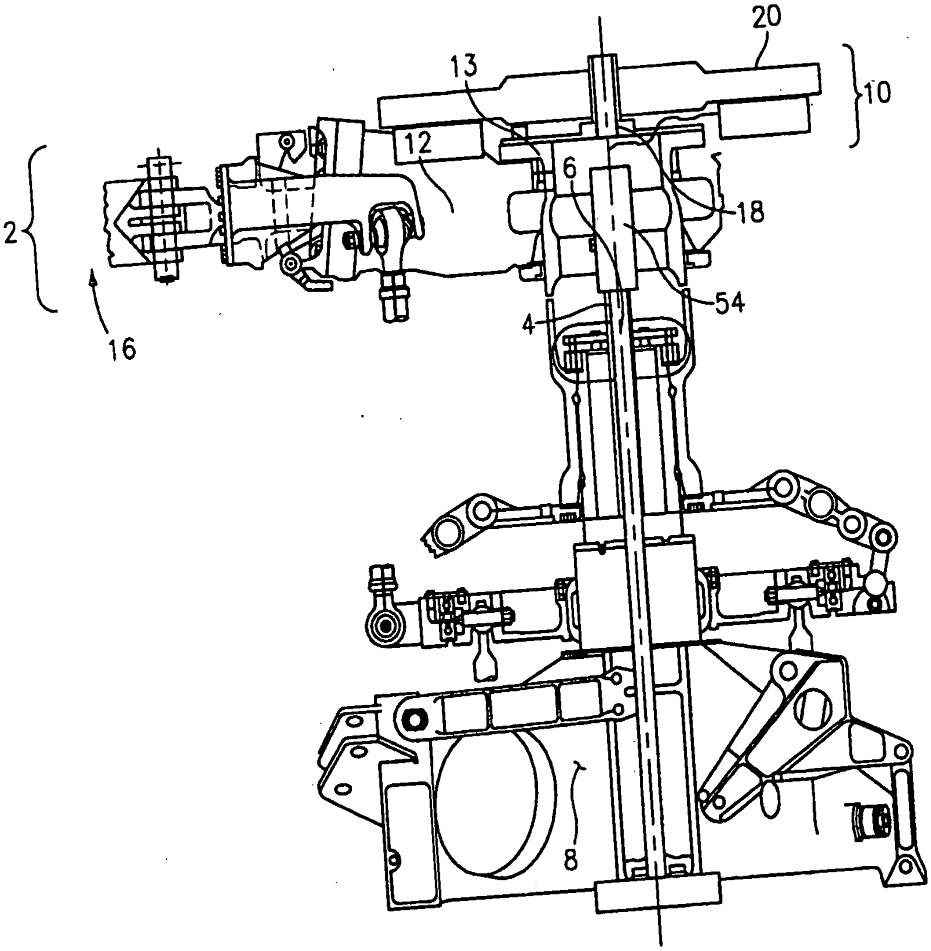

FIG. 2

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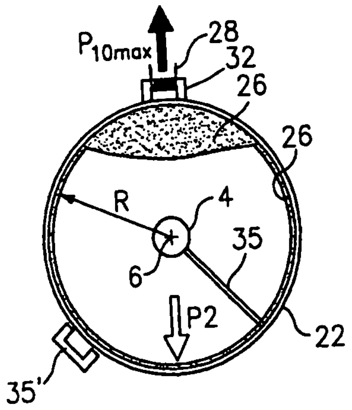

FIG. 3a

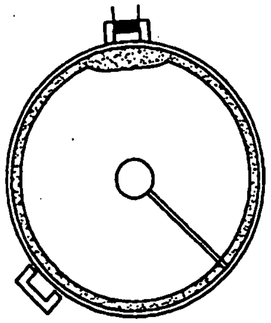

FIG. 3b

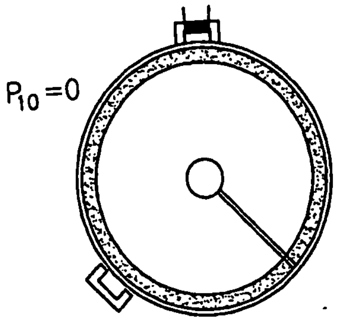

FIG. 3c

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REPLACEMENT SHEET
Serial No. 10/685,053; Applicant: Welsh; Filing date: 10/14/2003
ACTIVE FORCE GENERATION/ISOLATION SYSTEM EMPLOYING
MAGNETO RHEOLOGICAL FLUID (MRF)

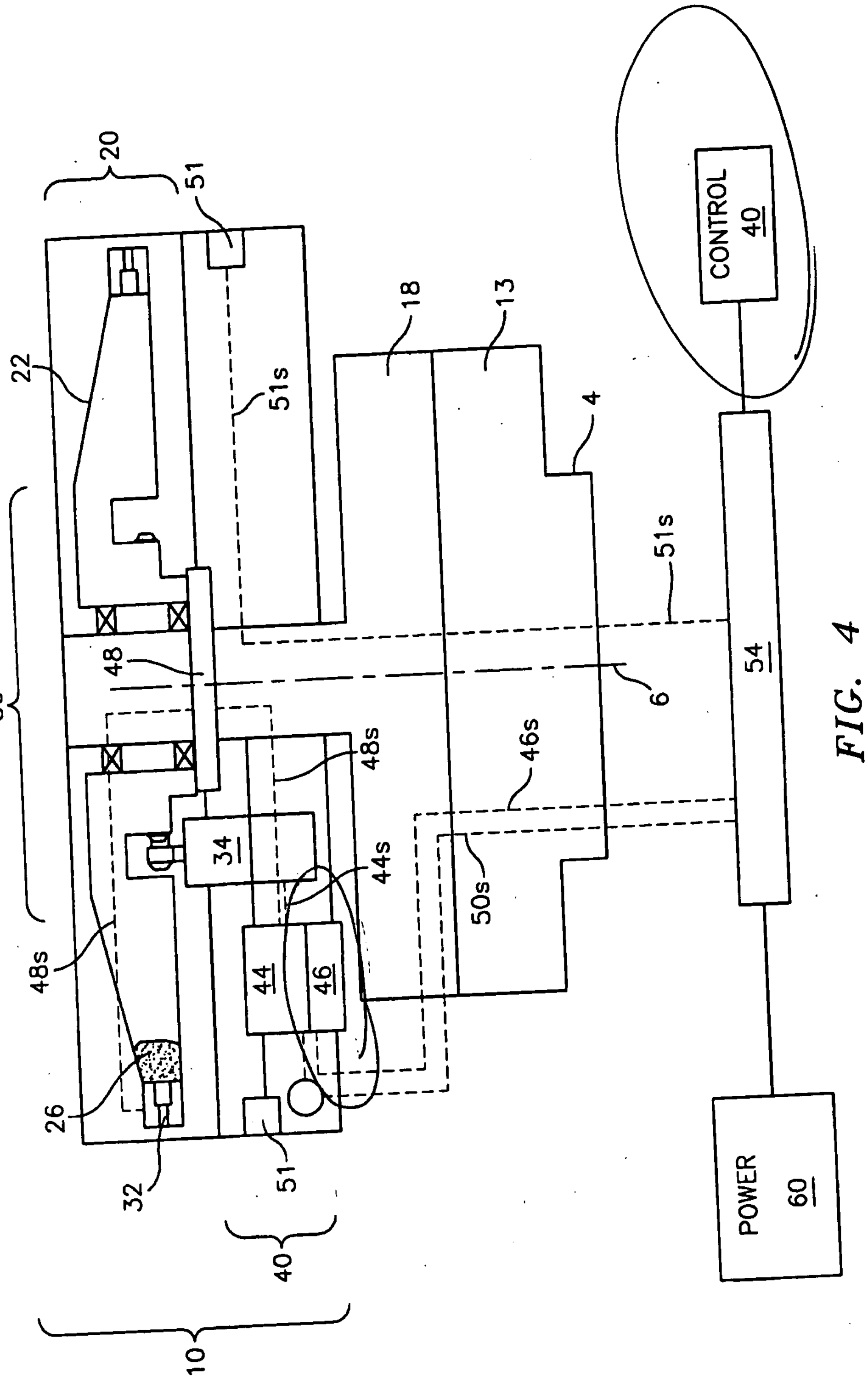

FIG. 4

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REPLACEMENT SHEET
Serial No. 10/685,053; Applicant: Welsh; Filing date: 10/14/2003
ACTIVE FORCE GENERATION/ISOLATION SYSTEM EMPLOYING
MAGNETO RHEOLOGICAL FLUID (MRF)

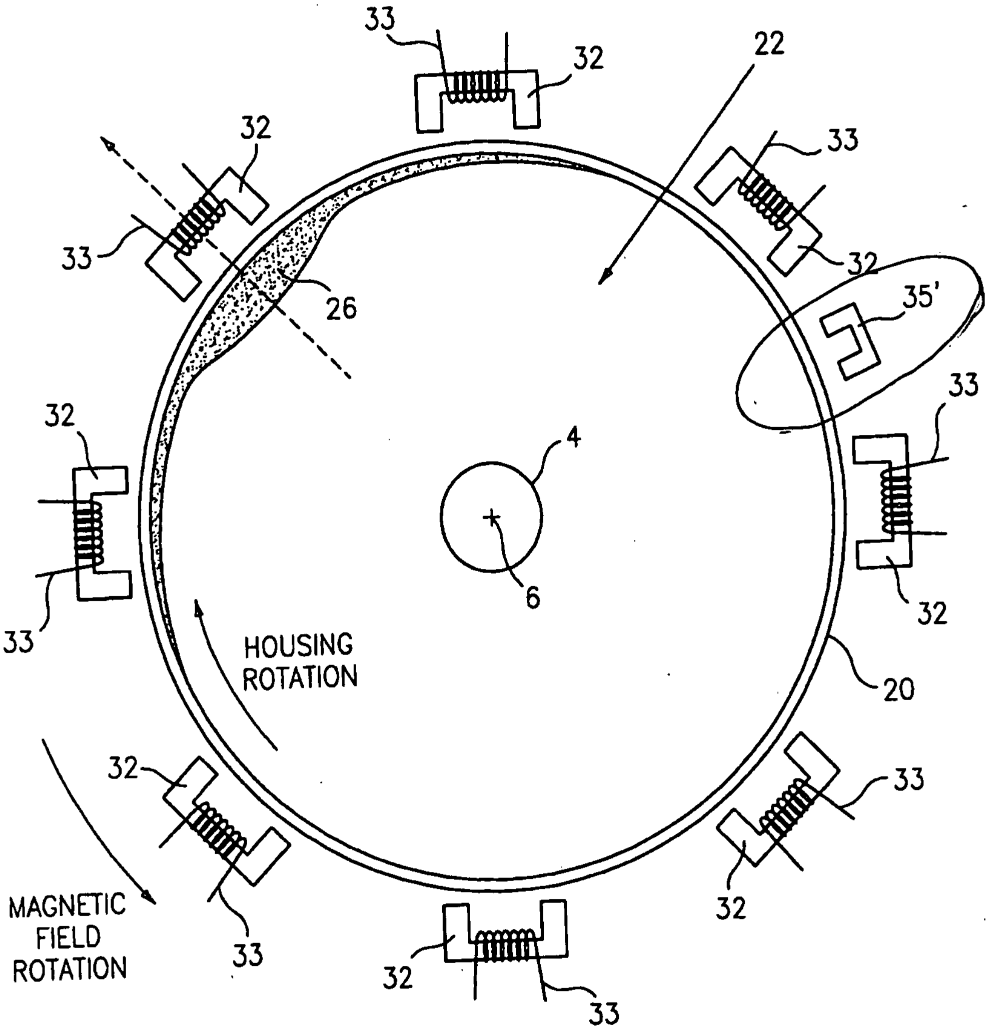

FIG. 5

NOT approved
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